SHIELD CONTINUITY

Contents

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers, contractors and other interested parties with technical information for use in the design and construction of REA borrowers telephone systems. Discussion is presented of various techniques that may be employed to determine if the cable shield is continuous from end to end.

1.2 The determination that cable shields are continuous from end-to-end, while one of the time consuming operations during noise investigations, is also one of the most important. In addition to the relationship between shield continuity and telephone system noise many protection problems are also directly attributable to shielding problems.

1.21 Where there is an open shield along a cable shielding effectiveness is lost and harmonic frequency noise to ground levels will approach those associated with unshielded conductors. Should the shield circuit not be open but have a high resistance bond serious degradation of shielding efficiency can occur.

1.22 Even though shielding effects are minimal at the fundamental frequencies they are important in reducing the high voltage levels induced in telephone systems due to power system faults and nearby lightning strokes. A continuous and effective shielding system will dissipate this energy effectively and thus reduce the chance for damage in the telephone system.

1.3 When a high value of power influence is found on cable pairs it may be an indication of excessive power system interference. It is equally likely to be an indication that there is either an open shield or a high resistance connection along the cable route.

1.4 It is usually difficult to find the location of shielding problems except by systematically inspecting and testing at each pedestal or splice location along the route. There are two areas of concern; poor or open bonds at splice locations and open shields between splices (usually due to damage).

1.5 Many problems can be experienced between the cable shield and associated bonding connector. Bonding problems can sometimes be identified by physical inspection of the splice. Ground connections at the lug should be tightened and the bonding wires moved to determine if solidly connected. If movement is observed either at the cable bonding point or at the grounding lug, repairs should be made.

1.6 Four methods for determining shielding continuity are presented in this section. Each method has some limitations which should be considered when deciding the appropriate one to use for a particular situation.

1.61 The end-to-end shield continuity check discussed in Paragraph 2 provides an indication of the shield effectiveness along the entire cable route. It does not provide any information that would identify the location(s) of the problem(s).. The real value of this test, where sufficient idle pairs are available, appears to be a determination whether or not additional shield testing is necessary along a cable route.

1.62 Use of the wheatstone bridge as presented in Paragraph 3 will usually find shield problems located between splices. Intermittent problems in bonding connections to the cable shield can also be found. This test is not always sensitive enough to detect minor problems which can result in shielding degradation.

1.63 Shield splice continuity testing is a sensitive method for determining the effectiveness of bonding connections across a splice. Problems between splices can usually be detected by an experienced tester. Positioning of the probe(s) is critical and dirt on the sheath can effect the results. It is important that the tester be familiar with the test set limitations discussed in Paragraph 4.

1.64 Measurement of shield current appears to be the most sensitive test procedure available for determining shield continuity. There are fewer limitations as discussed in Paragraph 5 than associated with the other test procedures.

1.7 Refer to TE&CM Section 451, Paragraph 5, for a discussion of shielding theory.

2. END-TO-END SHIELD CONTINUITY CHECK

2.1 Before initiating a time-consuming program of checking each bond and ground along a cable route, a check of the overall cable shield effectiveness is recommended. Such a procedure will determine positively if there is a necessity for checking at each splice location.

2.2 Select 15-25 spare pairs in the cable (in smaller pair count cables 5-10 pairs) and provide a means for grounding all of the selected pairs simultaneously at both the central office MDF and the far end of the cable in question. The number of pairs selected is determined by the size(s) of the cable(s) under evaluation. The resistance of the grouped pairs in parallel from end-to-end, should be approximately equal to the total resistance of the cable shield. The cable shield resistance values for various shield materials are shown in Table 1 & 2. Table 3 gives the resistance of various combinations and gauges of cable pairs in parallel. Load coil resistance need not be considered since it is small compared to conductor resistance. Where sufficient spare pairs are not available for this test, consideration should be given to taking working pairs out of service for the short period of the test.

CABLE PAIRS	SHIELD TYPE															
	5 mil. Cu				10 mil. Cu				8 mil. Al				6 mil. Cu-S			
	26	24	22	19	26	24	22	19	26	24	22	19	26	24	22	19
6	-	1.59	1.48	1.27	-	0.73	0.68	0.59	-	1.63	1.52	1.31	-	1.83	1.70	1.47
12	-	1.33	1.20	0.92	-	0.61	0.56	0.42	-	1.37	1.24	0.94	-	1.53	1.39	1.06
18	-	1.29	1.03	0.79	-	0.57	0.48	0.37	-	1.26	1.06	0.82	-	1.42	1.19	0.91
25	1.30	1.07	0.99	0.71	0.60	0.49	0.43	0.33	1.34	1.10	0.96	0.73	1.50	1.23	1.07	0.82
50	1.05	0.86	0.72	0.50	0.48	0.39	0.33	0.23	1.08	0.88	0.74	0.52	1.21	0.99	0.83	0.58
75	0.99	0.74	0.60	0.41	0.43	0.34	0.28	0.19	0.96	0.76	0.61	0.43	1.07	0.85	0.69	0.48
100	0.84	0.66	0.53	0.38	0.39	0.30	0.25	0.17	0.87	0.68	0.55	0.39	0.97	0.76	0.61	0.43
150	0.70	0.55	0.44	0.31	0.32	0.25	0.20	0.14	0.72	0.56	0.45	0.32	0.81	0.63	0.51	0.36
200	0.60	0.45	0.39	0.27	0.28	0.21	0.18	0.13	0.62	0.47	0.40	0.28	0.69	0.52	0.45	0.32
300	0.52	0.40	0.32	0.29	0.24	0.19	0.15	0.11	0.53	0.41	0.33	0.24	0.60	0.46	0.37	0.27
400	0.45	0.35	0.28	-	0.21	0.16	0.13	-	0.47	0.36	0.29	-	0.52	0.40	0.33	-
600	0.37	0.28	0.23	-	0.17	0.19	0.11	-	0.39	0.29	0.24	-	0.43	0.33	0.27	-

SHIELD RESISTANCE PER KILOFOOT
Filled Cable

TABLE 1

CABLE PAIRS	SHIELD TYPE															
	5 mil. Cu				10 mil. Cu				8 mil. Al				6 mil. Cu-S			
	26	24	22	19	26	24	22	19	26	24	22	19	26	24	22	19
6	-	1.76	1.63	1.27	-	0.81	0.75	0.59	-	1.81	1.68	1.31	-	2.03	1.88	1.47
12	-	1.48	1.33	1.05	-	0.68	0.61	0.48	-	1.52	1.37	1.08	-	1.70	1.53	1.21
18	-	1.38	1.16	0.89	-	0.64	0.54	0.41	-	1.49	1.20	0.92	-	1.60	1.34	1.03
25	1.41	1.29	1.03	0.79	0.65	0.57	0.48	0.37	1.46	1.26	1.06	0.82	1.63	1.42	1.19	0.91
50	1.14	0.96	0.81	0.59	0.53	0.44	0.38	0.27	1.19	0.99	0.84	0.61	1.32	1.10	0.94	0.68
	)0	0.84	0.69	0.50	0.46	0.39	0.32	0.23	1.03	0.87	0.71	0.52	1.15	0.97	0.80	0.58
	90	0.76	0.61	0.44	0.42	0.35	0.28	0.20	0.93	0.79	0.63	0.46	1.04	0.88	0.70	0.51
	76	0.63	0.51	0.36	0.35	0.29	0.23	0.17	0.78	0.65	0.52	0.37	0.87	0.73	0.59	0.42
	9	0.54	0.45	0.32	0.31	0.25	0.21	0.15	0.70	0.55	0.46	0.33	0.78	0.62	0.52	0.37
	9	0.45	0.37	0.26	0.27	0.21	0.17	0.12	0.59	0.47	0.39	0.27	0.66	0.52	0.43	0.30
	2	0.41	0.33	0.23	0.24	0.19	0.15	0.11	0.53	0.42	0.34	0.24	0.60	0.47	0.38	0.27
	3	0.34	0.27	-	0.20	0.16	0.11	-	0.44	0.35	0.27	-	0.49	0.39	0.31	-

SHIELD RESISTANCE PER KILOFOOT
Air Core Cable

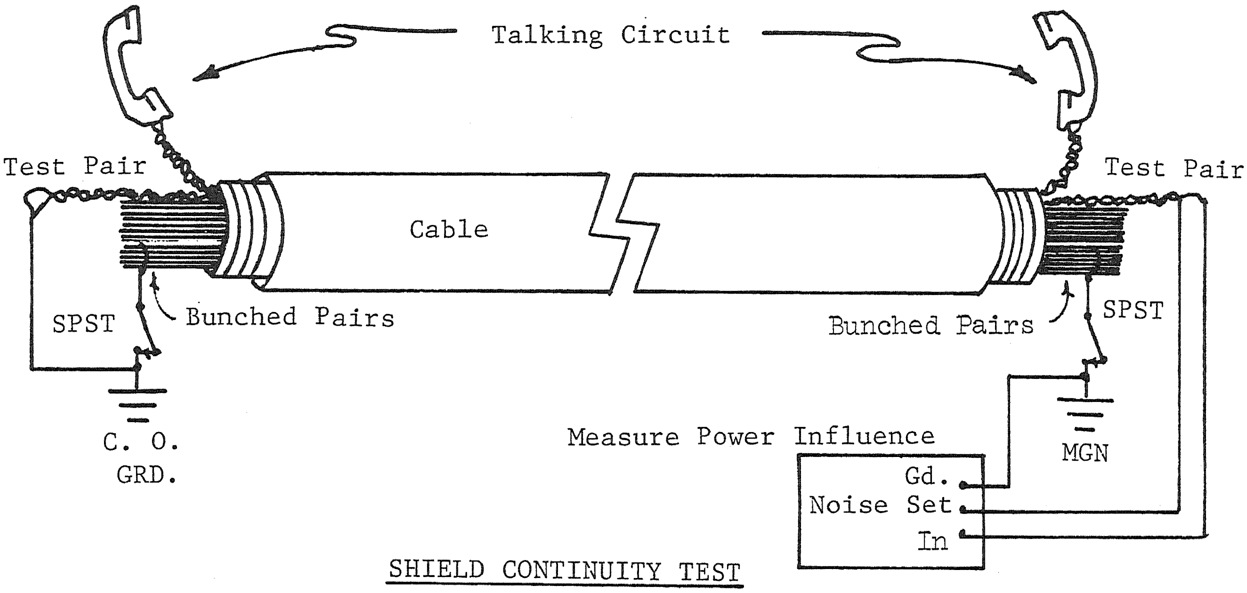
TABLE 2

RESISTANCE OF PARALLEL CABLE PAIRS

NO.		26		24		22		19	
Prs.	Cond.	Ω/KF.	Ω/MI.	Ω/KF.	Ω/MI.	Ω/KF.	Ω/MI.	Ω/KF.	Ω/MI.
3	6	6.9	36.7	4.3	22.8	2.7	14.3	1.3	7.1
6	12	3.5	18.3	2.2	11.4	1.4	7.1	0.7	3.5
9	18	2.3	12.2	1.4	7.6	0.9	4.8	0.5	2.4
12	24	1.7	9.2	1.1	5.7	0.7	3.6	0.34	1.8
15	30	1.4	7.3	0.9	4.6	0.54	2.9	0.27	1.4
18	36	1.2	6.1	0.7	3.8	0.45	2.4	0.22	1.2
21	42	1.0	5.2	0.6	3.3	0.39	2.0	0.19	1.0
24	48	0.9	4.6	0.54	2.9	0.34	1.8	0.17	0.9
27	54	0.8	4.1	0.48	2.5	0.3	1.6	0.15	0.8

TABLE 3

2.3 A talking circuit should be established between the end of the cable and the central office. A working pair can then be selected in the cable and the power influence on it measured at the far end (Figure 1) to the central office quiet termination. The selected pairs, shorted together, are then grounded simultaneously at both ends and the power influence measured on the working pair. If there is no working pair, the pair can be shorted and grounded at the main frame for the test.



SHIELD CONTINUITY TEST

FIGURE 1

Caution: Hazardous Voltages may be induced on the bunched conductors if there is an open shield. Extreme caution should be used when performing this test.

2.31 Since the grouped pairs in this test are to provide a simulation of the cable shield, it is important that good grounds are provided at both ends. At the central office, the office ground will be acceptable, and in the field a power system neutral ground is preferred since the ground resistance should be low (i.e., less than 5 ohms).

2.4 If the recorded value of power influence from the second measurement is 1 to 3 dB less than obtained from the first measurement, the cable shield can be considered to be in good condition.

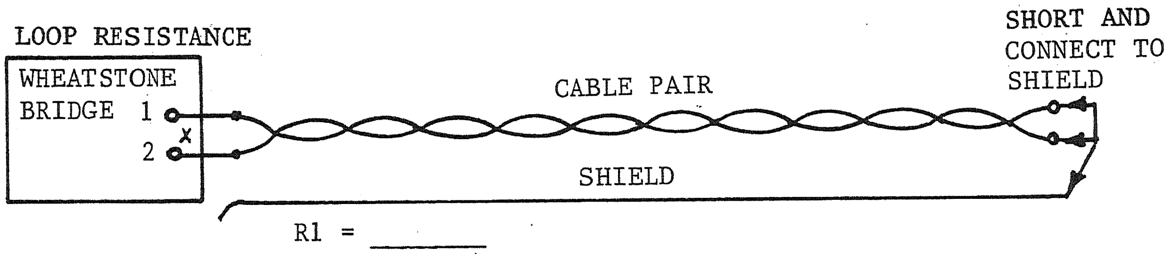
2.5 When a cable shield is continuous, end-to-end, adding grouped and shorted pairs grounded at both ends, connects these pairs in parallel with the cable shield and reduces the effective shield resistance. This will improve the shield efficiency and produce a small reduction in power influence. Should there be an open or high resistance connection along the shield, the grounded pairs become an

effective shield and the magnitude of power influence will be significantly reduced, usually by more than 6 dB. When a faulty shield is indicated by this test, checking of the shield continuity should be initiated section by section and through the splices.

3. SHIELD RESISTANCE USING WHEATSTONE BRIDGE

3.1 This test is effective for determining condition of the shield between splices. It can also give some indication of the effectiveness of the connection between the bonding harness and the shield, although it is not as sensitive as a shield continuity test set.

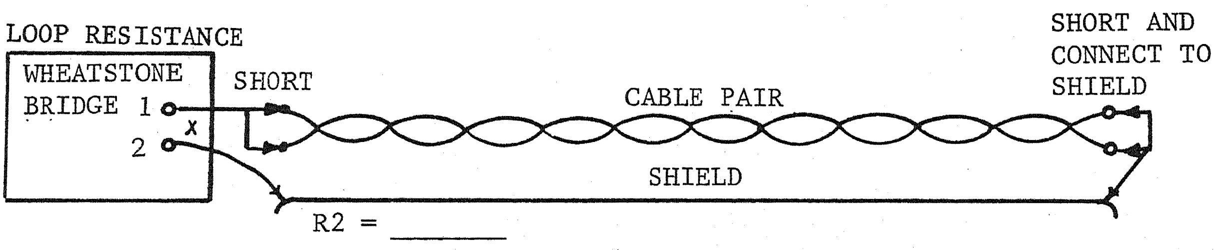
3.2 Using a wheatstone bridge, measure the loop resistance (R1) of an idle pair between two pedestals or splices (Figure 2). Record this resistance. This can be done with the pair shorted at the far end and connected to the cable shield.



SHIELD CONTINUITY WITH WHEATSTONE BRIDGE - LOOP RESISTANCE

FIGURE 2

3.3 Short tip and ring of the pair at measuring end and connect to one terminal of the wheatstone bridge. Connect shield to other terminal of the bridge. Measure loop resistance (R2) and record the value (Figure 3).



SHIELD CONTINUITY WITH WHEATSTONE BRIDGE - SHIELD RESISTANCE

FIGURE 3

The shield resistance (R_s) is: $R_s = R2 - \frac{R1}{4}$

3.4 If the measured shield resistance exceeds the estimated shield resistance by twenty-five percent, it is likely that a shield problem exists. An open shield is easy to identify since the difference between measured and estimated values will be very great.

4. SHIELD SPLICE CONTINUITY TESTER

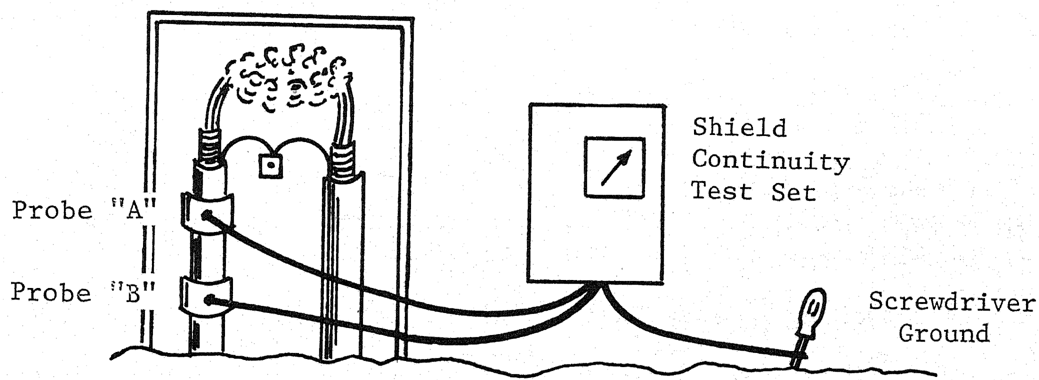
4.1 A shield splice continuity test set can be used to effectively determine the integrity of bonding between cable shields at a splice location. An experienced operator can also detect open shields between splices.

4.2 The test set is essentially a sensitive electrostatically coupled voltmeter. All cable shields have some 60 Hertz voltage and its harmonics present. The magnitude of the voltage is dependent upon several factors.

4.3 When a bond across a splice between two cable shields is good, the same potential to ground will appear on both sides of the splice. Should the bond be open or defective, a different voltage will appear on each side of the splice. Measurement of the differential voltage across the splice and the voltage to ground on each side will determine the quality of the bond between the shields of the cable involved.

4.4 The manufacturers recommended method for making splice continuity tests should be followed wherever possible.

4.41 A reference measurement should be taken by applying the probes to the same side of the cable sheath (both probes on one side of the splice) as shown in Figure 4, and recording the reading. Theoretically, there should be no reading but slight unbalances will result in a differential reading.

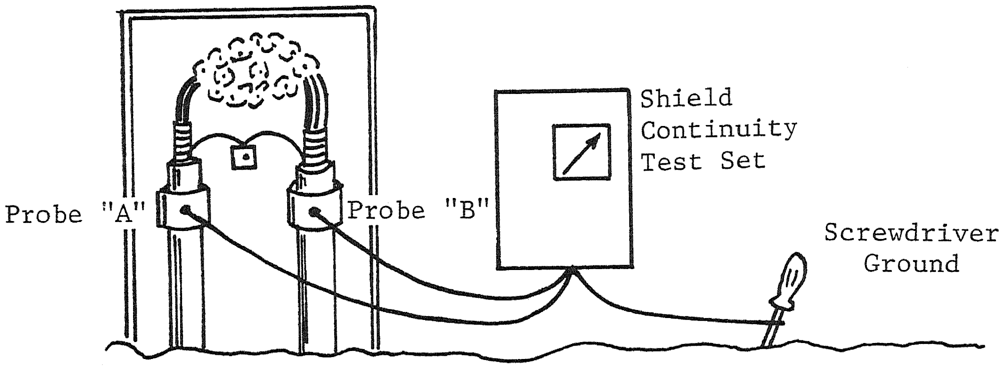


INITIAL DIFFERENTIAL READING

FIGURE 4

4.42 At the time the reference differential voltage is measured and the splice is measured, the voltage to ground on each probe should be measured and recorded. If no current is flowing in the shield, these voltages should be very close (0.02 dB). If current is flowing in the shield circuit, or if there is a defective bond, there will be a larger difference.

4.43 The probes are then placed across the splice as shown in Figure 5 and another reading is taken and recorded. If the bond between the two shields is good, there should be little difference between the two sets of readings. Should the values differ by more than about 2 dB, trouble in the bond is indicated. An open bond will produce a difference of 15 dB or greater. Smaller differences between 2 and 15 dB) usually indicates a high resistance connection in the bonding circuit.



MEASUREMENT OF SPLICE BONDING CONTINUITY

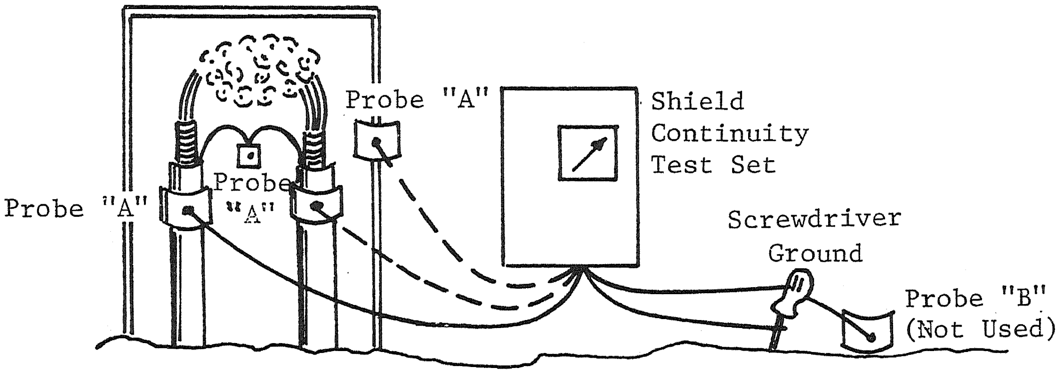
FIGURE 5

4.44 Intermittent conditions can usually be detected by moving the cable and wire of the bonding connector. When a problem exists the meter will move erratically as the components are moved.

4.45 Sometimes erratic meter readings will be observed without physical movement of the cable and the bonding connector wire. This condition may be caused by intermittent bonding connections or by missing grounds near the point of measurement. When grounds are missing, induced voltages on the shield will fluctuate sufficiently to give erratic readings on the measuring device.

4.5 When measuring splices in pedestals along buried cable routes, often there is not enough cable length in the pedestal for making a reference differential voltage reading. These splices may be effectively checked using a single probe and ground connection. This suggested method of operation eliminates the problems associated with using two probes in small pedestals. There is only one probe to position and the operator has two hands available for this operation.

4.51 With the single probe method voltage-to-ground is measured on each cable shield within the pedestal as shown in Figure 6. If the pedestal is metal the voltage-to-ground should be measured on it. Since with proper shielding everything, including the pedestal, should be at the same potential all readings should be the same. Where differences greater than 2 dB are found, there is a defective bond.



SINGLE PROBE METHOD

FIGURE 6

4.52 When an indication of a defective bond is found, the probe can be placed on the bonding wires. When a large voltage difference is found between a bonding wire and its associated shield, the problems will be in the connection between the two.

4.6 It is recommended that shield continuity tests be started at the central office, working from there toward the subscriber end. Each shield problem should be corrected when it is found before proceeding with further tests. Measurements made beyond an uncorrected problem may be in error and additional shielding problems might not be detected.

4.7 The magnitude of the voltage-to-ground at each splice location should be recorded. If all bonds and ground connections are good, the magnitude of the voltage to ground should rise slowly as the distance from the central office increases and then decrease slowly as a ground is approached in the field. Where a sudden rise or fall in potential is found between two adjacent pedestals the shield continuity between the pedestals should be measured with a wheatstone bridge as described in Paragraph 3.1. Many open shields between pedestals have been found using this method.

4.8 As with all test equipment, the manufacturers instructions for the particular piece of test equipment should be studied before using the equipment.

5. SHIELD CURRENT MEASUREMENTS

5.1 Measurement of the current on a telephone cable shield can effectively determine the condition of the shielding circuit. Problems in the shield between splice locations, shield bonding connectors, connections to grounds at the ends of drops and taps, etc., can be detected with this technique.

5.11 A clamp-on ammeter is utilized to measure the current magnitude flowing in the shield circuit. A clamp-on current adapter designed for use with a shield splice continuity test set can be used for this purpose. The clamp-on adapter may also be used with a noise measuring set. Due to its portability a shield continuity test set is most convenient.

5.111 The following discussion of specific test equipment produced by a single manufacturer for completing shield current measurements does not constitute an endorsement of these products. It further does not indicate the measurements cannot be performed using other manufacturers test equipment which may be capable of making the described tests. At the time of this writing they were the only ones known to be available for making the measurements.

5.112 The tests described can be completed with the Wilcom Products, Inc., T124 Shield Splice Continuity Test Set and T172 Current Adapter. There are two models of the T124 in use. The early model requires a 45-volt battery while the later model uses five 9-volt batteries. Table 4A has been prepared for converting the dB readings obtained with T124 test sets from serial number 1 through 2222 to current values. When the T124 test set has the serial number 2223 or higher use Table 4B for this conversion.

5.113 The T172 Current Adapter may also be used with a noise measuring set for the measurement of shield current. When making these measurements set the noise measuring set for 600 ohm TERM and 3kHz Flat. Table 5A has been prepared for converting the dBrn readings from the noise measuring set to current values.

5.114 The same manufacturer is also producing a T304 Meter and T305 Current Probe which provide direct measurement of shield current from 10 milliamperes to 100 amperes. This is an ideal tool for locating cable shield problems by measurement of shield current.

5.115 A T305 Current Adapter can also be used with a noise measuring set for measuring shield current. When used for performing these measurements set the noise measuring set for 600 ohm BROG and 3kHz Flat. Table 5B has been prepared for converting the dBrn readings from the noise measuring set to current values.

5.1151 For individuals who find it more convenient to use a calculator the nominal output of the T305 is 24.5 mV/ampere. With a NMS set as described in Paragraph 5.115 the reading on the dBrn scale is in dB above one milliampere.

TABLE 4A

Conversion From Decibel Reading to Current in Milliamperes

T124 Shield Continuity Test Set and T172 Current Adapter
(For T124 using a 45-volt battery)

0		-10		-20		-30		-40		-50	
dB	Amp	dB	Amp	dB	Amp	dB	mA	dB	mA	dB	mA
-0.5	29.85	-10.5	9.44	-20.5	2.99	-30.5	944	-40.5	299	-50.5	94
-1.0	28.18	-11.0	8.91	-21.0	2.82	-31.0	891	-41.0	282	-51.0	89
-1.5	26.61	-11.5	8.41	-21.5	2.66	-31.5	841	-41.5	266	-51.5	84
-2.0	25.12	-12.0	7.94	-22.0	2.51	-32.0	794	-42.0	251	-52.0	79
-2.5	23.71	-12.5	7.50	-22.5	2.37	-32.5	750	-42.5	237	-52.5	75
-3.0	22.39	-13.0	7.08	-23.0	2.24	-33.0	708	-43.0	224	-53.0	71
-3.5	21.14	-13.5	6.68	-23.5	2.11	-33.5	668	-43.5	211	-53.5	67
-4.0	19.95	-14.0	6.31	-24.0	2.00	-34.0	631	-44.0	200	-54.0	63
-4.5	18.84	-14.5	5.96	-24.5	1.88	-34.5	596	-44.5	188	-54.5	60
-5.0	17.78	-15.0	5.62	-25.0	1.78	-35.0	562	-45.0	178	-55.0	56
-5.5	16.79	-15.5	5.31	-25.5	1.68	-35.5	531	-45.5	168	-55.5	53
-6.0	15.85	-16.0	5.01	-26.0	1.59	-36.0	501	-46.0	159	-56.0	50
-6.5	14.96	-16.5	4.73	-26.5	1.50	-36.5	473	-46.5	150	-56.5	47
-7.0	14.13	-17.0	4.47	-27.0	1.41	-37.0	447	-47.0	141	-57.0	45
-7.5	13.34	-17.5	4.22	-27.5	1.33	-37.5	422	-47.5	133	-57.5	42
-8.0	12.59	-18.0	3.98	-28.0	1.26	-38.0	398	-48.0	126	-58.0	40
-8.5	11.89	-18.5	3.76	-28.5	1.19	-38.5	376	-48.5	119	-58.5	38
-9.0	11.22	-19.0	3.55	-29.0	1.12	-39.0	355	-49.0	112	-59.0	36
-9.5	10.59	-19.5	3.35	-29.5	1.06	-39.5	335	-49.5	106	-59.5	34
-10.0	10.0	-20.0	3.16	-30.0	1.00	-40.0	316	-50.0	100	-60.0	32

TABLE 4B

Conversion From Decibel Reading to Current in Milliamperes

T124 Shield Continuity Test Set and T172 Current Adapter
(For T124 using five 9-volt batteries)

0		-10		-20		-30		-40		-50	
dB	Amp	dB	Amp	dB	mA	dB	mA	dB	mA	dB	mA
-0.5	18.07	-10.5	5.71	-20.5	1806	-30.5	571	-40.5	181	-50.5	57
-1.0	17.06	-11.0	5.39	-21.0	1705	-31.0	539	-41.0	171	-51.0	54
-1.5	16.10	-11.5	5.09	-21.5	1610	-31.5	509	-41.5	161	-51.5	51
-2.0	15.20	-12.0	4.81	-22.0	1520	-32.0	481	-42.0	153	52.0	48
-2.5	14.35	-12.5	5.38	-22.5	1435	-32.5	454	-42.5	143	-52.5	45
-3.0	13.55	-13.0	4.28	-23.0	1355	-33.0	428	-43.0	136	-53.0	43
-3.5	12.79	-13.5	4.04	-23.5	1279	-33.5	404	-43.5	128	-53.5	40
-4.0	12.08	-14.0	3.82	-24.0	1207	-34.0	382	-44.0	121	-54.0	38
-4.5	11.40	-14.5	3.61	-24.5	1140	-34.5	361	-44.5	114	-54.5	36
-5.0	10.76	-15.0	3.40	-25.0	1076	-35.0	340	-45.0	108	-55.0	34
-5.5	10.16	-15.5	3.21	-25.5	1016	-35.5	321	-45.5	102	-55.5	32
-6.0	9.59	-16.0	3.03	-26.0	960	-36.0	303	-46.0	96	-56.0	30
-6.5	9.06	-16.5	2.86	-26.5	905	-36.5	286	-46.5	91	-56.5	29
-7.0	8.64	-17.0	2.70	-27.0	855	-37.0	271	-47.0	85	-57.0	27
-7.5	8.07	-17.5	2.55	-27.5	807	-37.5	255	-47.5	81	-57.5	26
-8.0	7.62	-18.0	2.41	-28.0	762	-38.0	241	-48.0	76	-58.0	24
-8.5	7.19	-18.5	2.27	-28.5	720	-38.5	228	-48.5	72	-58.5	23
-9.0	6.79	-19.0	2.15	-29.0	679	-39.0	215	-49.0	68	-59.0	21
-9.5	6.41	-19.5	2.03	-29.5	641	-39.5	203	-49.5	64	-59.5	20
-10.0	6.06	-20.0	1.91	-30.0	605	-40.0	191	-50.0	61	-60.0	19

TABLE 5A

Conversion From Decibel Reading to Current in Milliamperes

Noise Measuring Set and T172 Current Adapter

10		30		40		50		60		70		80	
dBrn	mA	dBrn	mA	dBrn	mA	dBrn	mA	dBrn	Amp	dBrn	Amp	dBrn	Amp
11	3	30.5	24	40.5	75	50.5	237	60.5	.75	70.5	2.37	80.5	7.5
12	3	31.0	25	41.0	79	51.0	251	61.0	.79	71.0	2.51	81.0	7.9
13	3	31.5	27	41.5	84	51.5	266	61.5	.84	71.5	2.66	81.5	8.4
14	4	32.0	28	42.0	89	52.0	282	62.0	.89	72.0	2.82	82.0	8.9
15	4	32.5	30	42.5	94	52.5	298	62.5	.94	72.5	2.98	82.5	9.4
16	5	33.0	32	43.0	100	53.0	316	63.0	1.00	73.0	3.16	83.0	10.0
17	5	33.5	34	43.5	106	53.5	335	63.5	1.06	73.5	3.35	83.5	10.6
18	6	34.0	35	44.0	112	54.0	354	64.0	1.12	74.0	3.54	84.0	11.2
19	6	34.5	38	44.5	119	54.5	375	64.5	1.19	74.5	3.75	84.5	11.9
20	7	35.0	40	45.0	126	55.0	398	65.0	1.26	75.0	3.98	85.0	12.6
21	8	35.5	42	45.5	133	55.5	421	65.5	1.33	75.5	4.21	85.5	13.3
22	9	36.0	45	46.0	141	56.0	446	66.0	1.41	76.0	4.46	86.0	14.1
23	10	36.5	47	46.5	149	56.5	473	66.5	1.49	76.5	4.73	86.5	14.9
24	11	37.0	50	47.0	158	57.0	501	67.0	1.58	77.0	5.01	87.0	15.8
25	13	37.5	53	47.5	168	57.5	530	67.5	1.68	77.5	5.30	87.5	16.8
26	14	38.0	56	48.0	178	58.0	562	68.0	1.78	78.0	5.62	88.0	17.8
27	16	38.5	60	48.5	188	58.5	595	68.5	1.88	78.5	5.95	88.5	18.8
28	18	39.0	63	49.0	199	59.0	630	69.0	1.99	79.0	6.30	89.0	19.9
29	20	39.5	67	49.5	211	59.5	668	69.5	2.11	79.5	6.68	89.5	21.1
30	22	40.0	71	50.0	224	60.0	707	70.0	2.24	80.0	7.07	90.0	22.4

NOTE: Set NMS for 600 ohm TERM and 3 kHz Flat

TABLE 5B

Conversion From Decibel Reading to Current in Milliamperes

Noise Measuring Set and T305 Current Probe

0		20		30		40		50		60		70		80	
dBrn	mA	dBrn	mA	dBrn	mA	dBrn	mA	dBrn	mA	dBrn	Amp	dBrn	Amp	dBrn	Amp
1	1	20.5	11	30.5	33	40.5	106	50.5	335	60.5	1.06	70.5	3.35	80.5	10.6
2	1	21.0	11	31.0	35	41.0	112	51.0	355	61.0	1.12	71.0	3.55	81.0	11.2
3	1	21.5	12	31.5	38	41.5	119	51.5	376	61.5	1.19	71.5	3.76	81.5	11.9
4	2	22.0	13	32.0	40	42.0	126	52.0	398	62.0	1.26	72.0	3.98	82.0	12.6
5	2	22.5	13	32.5	42	42.5	133	52.5	422	62.5	1.33	72.5	4.22	82.5	13.3
6	2	23.0	14	33.0	45	43.0	141	53.0	447	63.0	1.41	73.0	4.47	83.0	14.1
7	2	23.5	15	33.5	47	43.5	150	53.5	473	63.5	1.50	73.5	4.73	83.5	15.0
8	3	24.0	16	34.0	50	44.0	158	54.0	501	64.0	1.58	74.0	5.01	84.0	15.8
9	3	24.5	17	34.5	53	44.5	168	54.5	531	64.5	1.68	74.5	5.31	84.5	16.8
10	3	25.0	18	35.0	56	45.0	178	55.0	562	65.0	1.78	75.0	5.62	85.0	17.8
11	4	25.5	19	35.5	60	45.5	188	55.5	596	65.5	1.88	75.5	5.96	85.5	18.8
12	4	26.0	20	36.0	63	46.0	200	56.0	631	66.0	2.00	76.0	6.31	86.0	20.0
13	5	26.5	21	36.5	67	46.5	211	56.5	668	66.5	2.11	76.5	6.68	86.5	21.1
14	5	27.0	22	37.0	71	47.0	224	57.0	708	67.0	2.24	77.0	7.08	87.0	22.4
15	6	27.5	24	37.5	75	47.5	237	57.5	750	67.5	2.37	77.5	7.50	87.5	23.7
16	6	28.0	25	38.0	79	48.0	251	58.0	794	68.0	2.51	78.0	7.94	88.0	25.1
17	7	28.5	27	38.5	84	48.5	266	58.5	841	68.5	2.66	78.5	8.41	88.5	26.6
18	8	29.0	28	39.0	89	49.0	282	59.0	891	69.0	2.82	79.0	8.91	89.0	28.2
19	9	29.5	30	39.5	94	49.5	299	59.5	944	69.5	2.99	79.5	9.44	89.5	29.9
20	10	30.0	32	40.0	100	50.0	316	60.0	1000	70.0	3.16	80.0	10.00	90.0	31.6

NOTE: Set NMS for 600 ohm BRDG and 3kHz. Flat.

5.1152 This reading can be converted to milliamperes or amperes without any need for a special conversion table. The equation is:

$$I_{mA} = \log^{-1} \left(\frac{\text{dBrn (reading)}}{20}\right)$$

5.12 During acceptance testing of new cable plant there are two situations where application of this technique would be indicated. The first is an indication of cable shield problems where the end-to-end shield continuity test described in Paragraph 2 has been completed. The second is where the new cable is an extension or reinforcement of existing cable and there are not enough idle cable pairs available for the end to end test.

5.13 Testing should always be started at the central office main frame, moving progressively to each splice location until the far end of the cable is reached. When a problem is found it should be corrected before moving to the next location. Failure to do this can result in missing problems located further from the office. This will add unnecessary time to locate and correct all shielding problems along the cable route.

5.14 When a major shield problem is located a declining shield current will be found in several splice locations as the problem location is approached. It is recommended that these splice locations be remeasured after repair of the major fault to insure that a less severe problem has not been bypassed. Such problems can be masked by the effects of major defects along the cable shield.

5.2 The shield circuit along a cable has many potential paths to ground as shown in Figure 7. When making shield current tests along the main cable route all shield connections at a splice location, except the main route shield connections toward the office and the field, are assumed to be ground connections.

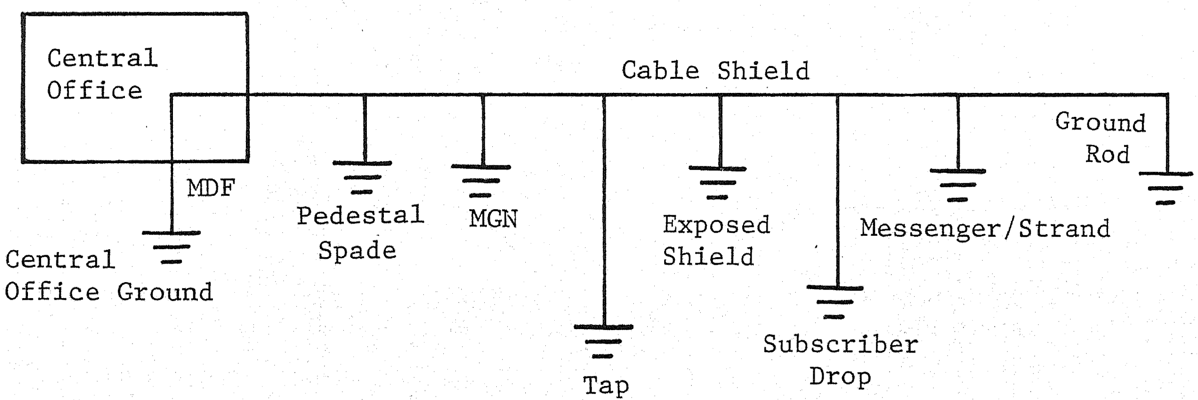


FIGURE 7

SHIELD GROUND CONNECTIONS

5.21 As stated, taps from the main cable route are treated as ground connections when testing along the main cable route. After completion of work along the main route each tap is studied individually. During testing along a tap route it is considered in the same manner as the main cable route discussed in Paragraph 5.2.

5.22 After all testing has been completed and problems corrected it is sometimes desirable to remeasure the shield currents at all splice locations a second time recording the results. This will provide a reference for comparison should future problems occur.

5.3 Shield current measurements are made by placing the clamp-on device around the wire or strap of the bonding harness, reading and recording the current. The readings when in dBrn, should be converted to current in amperes before recording. Measuring the current in the bonding wire or strap eliminates the longitudinal current flowing on the conductor bundle forming the cable core. Thus the reading is only the magnitude of the current flowing in the shielding circuit.

5.31 Measure the current in each bonding wire or strap in each pedestal or splice with the clamp-on device as shown in Figure 8A and record the results. Start at the office end of the cable route. In a pedestal there is no wire leading to the spade and sometimes the wire connection to a ground rod is not readily accessible. The current flowing to ground through these connections can be measured by clamping the device around all the bonding wires or straps leading to the common point as shown in Figure 8B.

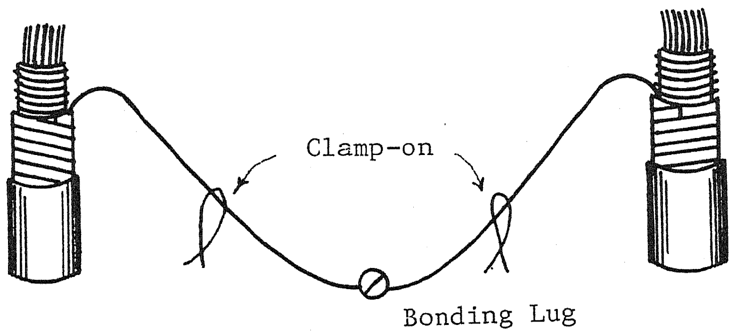


FIGURE 8A

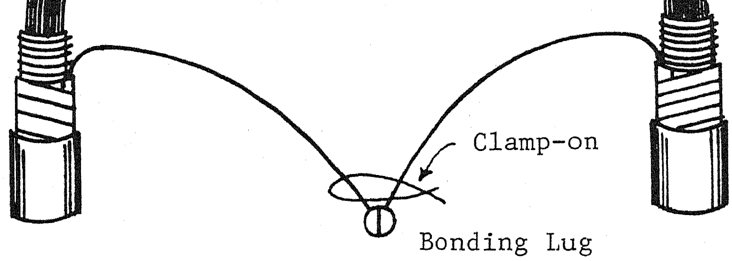


FIGURE 8B

MEASUREMENT OF SHIELD CURRENT

5.321 The total incoming current should be equal to the total outgoing current at any given point. Where there are only two or three directions (ground and/or office and field direction) to consider this determination is quite simple. The recorded current in either the office or field direction will equal the current in the other direction plus that in the ground connection as shown in Figure 9. A 10 percent tolerance should be allowed since the power influence is a variable factor and changes can occur during the measurements. Also in pedestals where long taps join the main cable varying phase angles may produce differences between incoming and outgoing currents.

Ped., Pole or Terminal No.	Office Side	Field Side	Ground Type	Current	Remarks
CO	-	890	CO		
B1	950	950			
B2	1000	800	B2R TAP	100	
			Drop	120	
B3	840	1200	MGN	350	
			PED	#	
			Drop	100	
			Drop	C	

NOTE: # Indicates no meter movement
C Indicates meter movement but no readable current

FIGURE 9
SAMPLE CURRENT MEASUREMENTS

5.322 There is an exception to the rule that total input current equals total the total output current. This can occur when a connection to the multigrounded neutral exists at the point of measurement. Due to the phase angle relationships between the current flowing in the power neutral and the cable shields large apparent differences may be found between ins and outs.

5.3221 Theoretically, if there is one ampere measured current toward the office and toward the field and both have the same phase angle no current will be measured toward the power neutral. When the phase angles are completely apposite, for example 0^{o} toward the office and 180^{o} toward the field, two amperes will be measured toward the power neutral. If the phase angle toward the office is 60^{o} and toward the field is 120^{o} (a 60^{o} phase angle difference) one ampere will be measured toward the neutral conductor. Thus, depending on the phase angle relationship in two directions, any current value between zero and the sum of two currents will be measured in the third.

5.3222 When measuring shield current where there is a connection to the multigrounded neutral first measure the current in each of the wires. Then measure the pair combinations (office-MGN, field-MGN, and office-field) as shown in Figure 8B. If the results of each of the combination measurements is essentially the same as the recorded current in the third wire the measurements can be accepted as correct. The bonding connections should be checked in the manner shown in Paragraph 5.33.

5.323 Where there are more than three connections to consider, such as, office, field, tap, drop, and ground rod or pedestal spade it is sometimes very difficult to identify the ins and outs by inspection. The correct direction of current flow can be determined by measurement. In the example shown in Figure 10 six measurements have been made and recorded. Inspection reveals there are several combinations that are essentially equal and the problem is to determine which is correct.

5.3231 First, assume that the current in the bonding wire or strap having the highest recorded value is flowing toward the bonding lug. In the example in Figure 10, the office direction has been selected. Next number the various directions as shown in the example with the selected wire designated 1. An arrow pointing down indicates current is flowing toward the common connection point. Place the clamp-on device around wires 1 and 2. If the resulting current is lower than that recorded for number 1, the current in the two wires is flowing in opposite directions. When it is higher the current flow is in the same direction. In the example, the current is lower so an arrow pointing up is placed by the 2 indicating the current is flowing away from the common connection point.

Ped., Pole or Terminal No.	Office Side	Field Side	Ground Type	Current	Remarks
C6-1	1↓950	2↑750	Ped.	3↓300	
			Drop	4↑120	
			Drop	5↑150	
			Tap	6↑260	
				220	↓1 + 2↑
				850	↓1 + 4↑
				800	↓1 + 5↑
				680	↓1 + 6↑
				1210	2 + 4 + 5 + 6

FIGURE 10
MULTIPLE SHIELD EXAMPLE

5.3232 Measure progressively through all combinations with the number 1 as shown in the example (1 & 4, 1 & 5 and 1 & 6). In the example it is not possible to measure the 1 and 3 combination directly since 3 is the pedestal spade. By inspection the current should be flowing toward the lug in the same direction as 1 to obtain equality. As a check of the results place the clamp-on device around the group of wires shown as having current flowing in the same direction which does not include the pedestal spade and verify that the current read is within 10 percent of the sum of the individual readings.

5.324 Should there still be a question after performing the measurements described in Paragraph 5.3231 as to the direction of the current in one of the bonding wires or straps it can be established by a direct measurement. Repeat the measurement of the wire in question and wire 1 but reverse the direction of the wire in question through the clamp-on device as shown in Figure 11. If the first recorded result of the measurement from Paragraph 5.3231 is higher the current in the two wires is flowing in the same direction. If the results of this second measurement is higher, the current is flowing in opposite directions or away from the common connecting point.

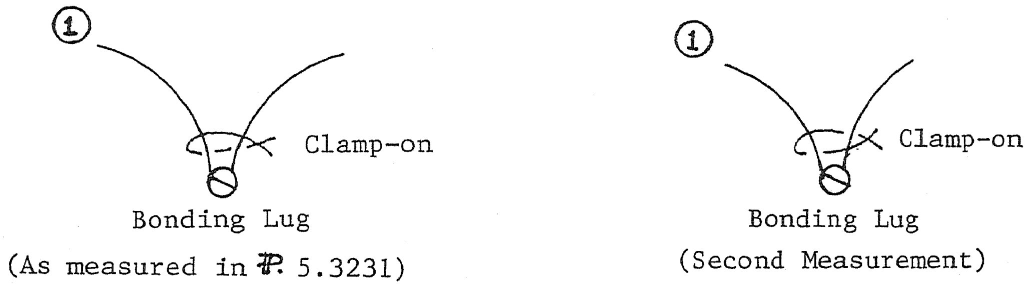


FIGURE 11
DETERMINING CURRENT DIRECTION

5.33 Valuable information can sometimes be obtaining by using a nearby ground connection to the multi-grounded neutral as a reference ground. This is accomplished by extending a wire from the ground wire on a power pole to a telephone pedestal and connecting it to the telephone cable shield.

5.331 This technique should be employed when there is a question that the magnitude of the shield current is too low. Such condition may be indicated when a sudden drop in shield current occurs over a length of three or four splice locations. Connecting the shield to a known low resistance ground such as the multigrounded neutral will provide an indication of the direction to a shield problem.

5.332 An example of this taken from the recorded results made during a noise investigation shows a shield current toward the office of 40mA and toward the field 5mA. After the connection was made to a nearby pole with a multigrounded neutral ground wire the measured shield current toward the office was 450mA and toward the field 9mA with a current of 500mA in the MGN connection. An open in the shield circuit was found in the next pedestal toward the field. After this was repaired the shield current in the original pedestal, after removal of the MGN connection, was 500mA in both the office and field connection.

5.34 The last operation at each location is the measurement of the bonding connection to the shield for each cable in the pedestal or splice point. For this measurement a single insulated wire about three feet long is needed with a test probe at each end. The test probes should have steel tips honed to a sharp needle point. It is advisable when performing these tests that a small oil stone be available for maintaining the sharp tips.

5.341 Place the clamp-on device around the cable below the bonding connection. Place one test probe point on the bonding wire or strap adjacent to but not touching, the bonding lug. With the other probe, while watching the test set meter, pierce the sheath between the bonding harness connection and the clamp-on device until contact is made with the shield as shown in Figure 12. If the dB reading changes by 0.5 dB or more, there is a problem and the bonding harness should be replaced. The bonding wire or strap should be moved during this measurement to detect any intermittent condition.

5.342 When there is no change in the meter reading move the probe from the bonding wire or strap to the bonding lug as shown in Figure 12. A change in the meter reading of 0.5 dB or more indicates a problem in the connection at the bonding lug and it should be remade. The bonding wire or strap should be moved at the point of connection with the bonding lug during this measurement to detect any intermittent condition.

5.343 This same procedure is followed for each cable entering the splice point. If a multigrounded neutral connection exists one probe should be placed on the wire outside the pedestal or splice point and the other on the bonding lug after placing the clamp-on device around the wire to the MGN beyond the probe location. A change of 0.5 dB or more indicates a problem in the connection to the bonding lug and it should be remade.

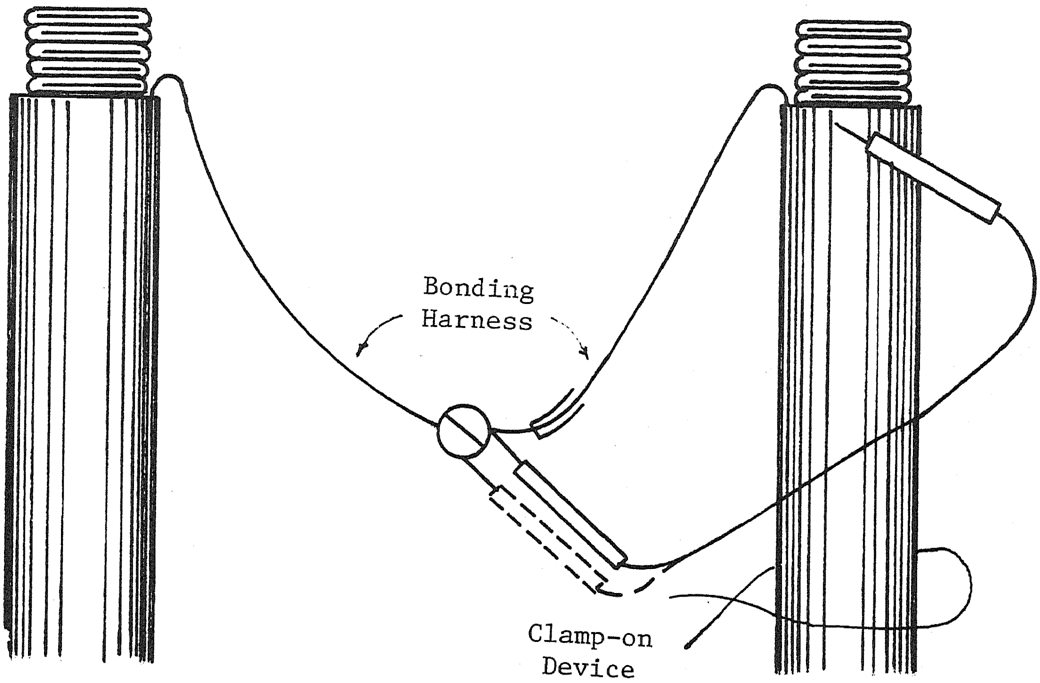


FIGURE 12
MEASUREMENT OF BONDING HARNESS CONNECTION

5.4 A suggested format for recording the results of shield current measurements is shown in Figure 13.

FIGURE 13

SHIELD CURRENT MEASUREMENT

SHEET_____ of_____

EXCHANGE_______________ LINE NO._______ DATE_______________

ED., POLE OR TERMINAL	OFFICE SIDE	FIELD SIDE	GROUND TYPE	CURRENT	COMMENTS